ROYAL HOLLOWAY, UNIVERSITY OF LONDON
BSc EXAMINATION 2021

CS1812: Object oriented programming II
CS1812R: Object oriented programming II – FOR FIRST SITS/RESIT CANDIDATES

Time allowed: **TWO hours**

Please answer **ALL** questions.

- Handwrite your answers on paper, and write your candidate number and the module number at the top of each page. Photograph/scan the pages and keep the original paper versions, as they may be required by the examiners.
- For each question you attempt, please clearly state the question number.
- Please DO NOT include your name or Student ID anywhere on your work.
- **Academic Misconduct:** We will check all assignments for academic misconduct. Suspected offences will be dealt with under the College's formal Academic Misconduct procedures. Please remember:
  - The work submitted is expected to be your own work and only your work. You may not ask for help from any source, or copy anyone else's work.
  - You must not give help to anyone else, including sending them any parts of the questions or copies of your solutions.
  - You must not discuss the questions or solutions with anyone else.
- **Submitting your work:**
  - Your document must be submitted through Moodle using the submission link in the module Moodle page. If possible please convert your document into a PDF document to make the submission process quicker and easier.
  - Emailed submissions will not be accepted.
  - **You must complete your exam upload within 1 hour of the exam finish time.**

1. This question is about writing classes and enums to represent particles in a physics simulation.

   (a) Write an enumerated type `Spin`, that contains four elements named `ZERO`, `ONE_HALF`, `ONE`, and `THREE_HALVES`. [5 marks]

   (b) Write a class `Particle`. The class should have the following.

   - Private fields: `name`, of type `String`; `mass`, of type `double`; `charge`, of type `int`; and `spin`, of the enumerated type `Spin`.
   - Public getters for each of the above fields.
   - A public constructor, that takes parameters of type `String`, `double`, `int`, and `Spin`, and uses these to initialise the fields.

   [10 marks]

   (c) Add a public instance method `equals(Object o)` to the `Particle` class that takes an object as an argument and returns a `boolean` indicating whether that object represents the same subatomic particle as the receiver. This method should check that:

   - the object passed as an argument is an instance of the `Particle` class;
   - the values of the `mass`, `charge`, and `spin` fields in the object passed as an argument are the same as those in the receiver object.

   [5 marks]

2. Consider the following two classes `MyClass` and `AnotherClass`, defined in different files:

```java
package rhul.mypackage;

import java.util.HashMap;

public class MyClass {
    int x;
    private HashMap<String,Integer> y;
    protected double z;
}
```

```java
import rhul.mypackage.*;

public class AnotherClass extends MyClass {
    int w;

    public AnotherClass(int w) {
        this.w = w;
    }

    public void foo(int w) {
        if (this.w > 0) {
            int t = 2;
            t = w + t;
        }
        else {
            int t = -2;
            t = w * t;
        }

        System.out.println("The value of t is: " + t);
    }

}
```

(a) Which packages are `MyClass` and `AnotherClass` in? [4 marks]

(b) Which instance variables of `MyClass` and `AnotherClass` are visible in the method `foo` of the class `AnotherClass`? Justify your answer. [5 marks]

(c) Compiling `AnotherClass` will indicate that there is an error in the method `foo`.

i. Explain what is causing the error. [3 marks]

ii. Modify the method `foo` so that it compiles correctly and the code

```
AnotherClass a = new AnotherClass(-3);
a.foo(4);
```

prints out "`The value of t is -8`". [3 marks]

3. Consider the following class.

```
class VendingMachine {
    protected int stockLevel;
    public VendingMachine(int initialLevel) {
        stockLevel = initialLevel;
    }
    public void dispense() {
        if (retrieve()) {
            System.out.println("Enjoy your drink!");
        } else { System.out.println("Nothing left!"); }
    }
    protected boolean retrieve() {
        if (stockLevel == 0) { return false; }
        stockLevel--;
        return true;
    }
}
```

(a) Write a class `SmartVendingMachine` that inherits from the `VendingMachine` above, for modelling a vending machine that can automatically refill itself. It should contain the following.

- A constructor that takes an `int` as a parameter and calls the superclass constructor to initialise the `stockLevel` field.
- A method overriding the `retrieve()` method from `VendingMachine` that: first checks the current stock level of the receiver and, if it is `1`, resets it to `5`; then returns the result of calling the `retrieve()` method from `VendingMachine`. Remember to use any appropriate @ annotations.

[8 marks]

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(b) Consider the following incomplete `main` method.

```
public static void main(String[] args) {
    VendingMachine m = /* missing code */
    for (int i = 0; i < 10; i++) {
        m.dispense();
    }
}
```

i. Complete the missing code to create an appropriate object for modelling a vending machine with an initial stock level of `5`, such that the result of executing the `main` method is to print out the text "`Enjoy your drink!`" ten times. [4 marks]

ii. What is the sequence of constructors from the `VendingMachine` and `SmartVendingMachine` classes that are called when the code you have given for the previous part is executed? [2 marks]

iii. What is the sequence of methods from the `VendingMachine` class and the `SmartVendingMachine` class that are called the first time the body of the `for` loop is executed? (Ensure that you write out the full name of each method, including the name of the class it is declared in). [6 marks]

4. This question is about exception handling. Consider the following incomplete method.

```
public static String getLine(int n, String fileName) {
    BufferedReader br = null;
    try {
        br = new BufferedReader(new FileReader(fileName));
    }
    catch(FileNotFoundException ex) {
        // catch block
    }
    finally {
        // finally block
    }
}
```

(a) Complete the method above so that it returns the `n`th line of the file given in `fileName` (for `n` = `0` it should return the first line). The method should return `null` if no such line can be found, or if an error has occurred whilst reading the file.

Use `readLine()` from the `BufferedReader` class to read each line of the file; this method returns the next line, or `null` if there are no lines left to read.

Reading the file may raise an `IOException`. Make sure that this is properly handled and that the `BufferedReader` is closed correctly. [11 marks]

(b) Write a class `LineNotFoundException` defining a custom exception. Indicate how you can modify your solution to part (a) so that `getLine` throws an instance of that exception when the file has fewer than `n+1` lines. [4 marks]

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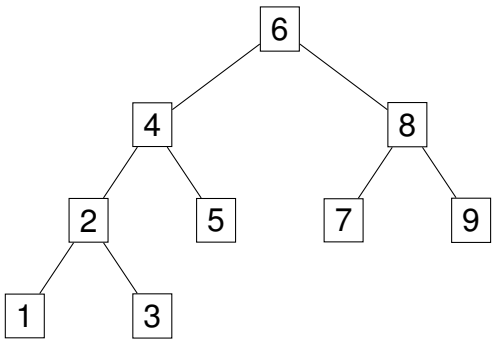
5. Consider the tree shown in the diagram below.



(a) Write out the sequence of values that would be obtained by the following traversals of the tree given above.

i. Pre-order depth-first traversal [4 marks]

ii. Breadth-first traversal [4 marks]

(b) Draw a single binary tree in which nodes contain one of the characters ‘B’, ‘O’, ‘S’, or ‘T’, such that an in-order depth-first traversal of the tree spells the word “BOOST” and a post-order depth-first traversal of the same tree spells the word “BOOTS”. [7 marks]

6. The following `binarySearch` method searches a sorted array of integers `arr` for a given integer `val`, looking between between positions `start` and `end` (inclusive).

```
boolean binarySearch(int[] arr, int val, int start, int end)
{
    if(start > end) {
        return false;
    }

    int middle = (start + end) / 2;

    if(arr[middle] == val) {
        return true;
    }
    else if (val < arr[middle]) {
        return binarySearch(arr, val, start, middle - 1);
    }
    else {
        return binarySearch(arr, val, middle + 1, end);
    }
}
```

   (a) Modify this method so that it can be used to search a generic list of type `ArrayList<T>`. Use the method `get(int index)` of `ArrayList` to retrieve the element of the list at position `index`. Add comments to the lines you needed to change.
   (**Hint:** The signature should require that the type parameter `T` implements the interface `Comparable<T>`. You can use the `compareTo` method from the `Comparable` interface to compare elements. Recall that `x.compareTo(y)` returns a negative integer, zero, or a positive integer if `x` is less than, equal, or greater than `y`, respectively.) [6 marks]

   (b) Write a static generic method `printSearch`, with a type parameter `T`, that takes as input two arguments `ArrayList<T> lst` and `T val`, and does not return any value. The method should do the following:

   - check if the list is sorted in ascending order and, if it is not, print out an error message;

- if the list is sorted, call the `binarySearch` method you have implemented for part (a) to search for the element `val` in the list `lst`, and prints out a message describing the search result.

You can use the `size()` method of `ArrayList` to get the number of elements in the list.

You should provide both the signature and the implementation of the method. [6 marks]

(c) What is the complexity of your `printSearch` method from part (b) applied to a list of size n? Justify your answer. [3 marks]

END